AN EXPLORATION CASE HISTORY: ANISOTROPIC DEPTH MIGRATION in the Central Alberta Foothills

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Abstract

A development well was proposed over a natural-gas field in the Central Alberta Foothills. The target was a thrust-sheet culmination less than 300 meters wide. The initial well location came from the interpretation of seismic data using poststack time migration, prestack time migration, and prestack depth migration. Each method offered imaging improvements over the previous, but there was little change in the imaging or location of the culmination of the structure. Once it was discovered that the well missed the target, a dip meter was acquired and the seismic data were reprocessed using anisotropic depth migration. The dip meter indicated that the well had missed the leading edge of the structure and the anisotropic depth migration shifted the structure 250 m toward the hinterland. The subsequent sidetrack to the correct position of the structure, indicated by the anisotropic depth migration, resulted in a successful gas well.

introduction

Geologic Setting

The exploration objective was a natural-gas development target in the Central Alberta Foothills. The target was interpreted to be carried on a major thrust sheet with a lateral extent of approximately 30 km trending in a NW-SE strike direction. Several producing wells exist on the field.

A well was proposed on the basis of a seismic line acquired by Response Seismic Surveys in 1992. The structural targets proposed for the well range in depths from 3000 to 3350 m and are located beneath the southwest flank of the triangle zone in the area.

Well B

The well was spudded from a surface location Northeast of the of the bottom-hole target. The processed versions of the Response Data Set available at the time of picking the location were poststack time migration, prestack time migration (Figure 1), and prestack depth migration (Figure 2). The prestack time and depth migrations improved reflector continuity on the flank of the structure, but no appreciable shifts in the seismic event at the target location were visible between the three different versions, as shown by the marker for Well B in Figures 1 and 2.

The primary seismic marker used in structural mapping in this area is the Jurassic Nordegg and the primary and secondary targets are presumed to be conformable above and below the Nordegg. The Nordegg reflector was targetted below location C on Figure 2, approximately 200 m west of the termination of the Nordegg reflector as shown in Figure 2. The well trajectory followed its proposed course, but at 3243 m depth, it was obvious from the samples from drilling and MWD logs that Well B had missed the main target.

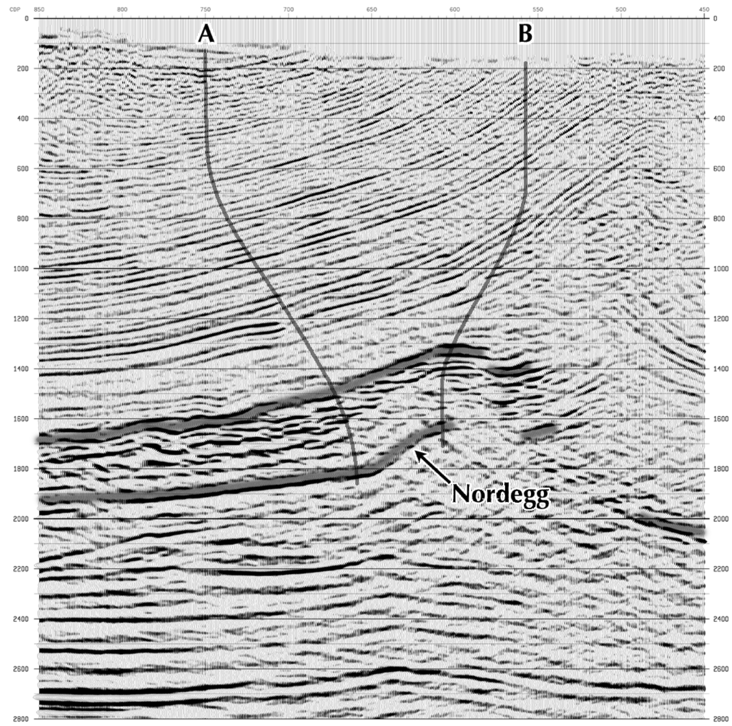

Figure 1. Prestack time migration.

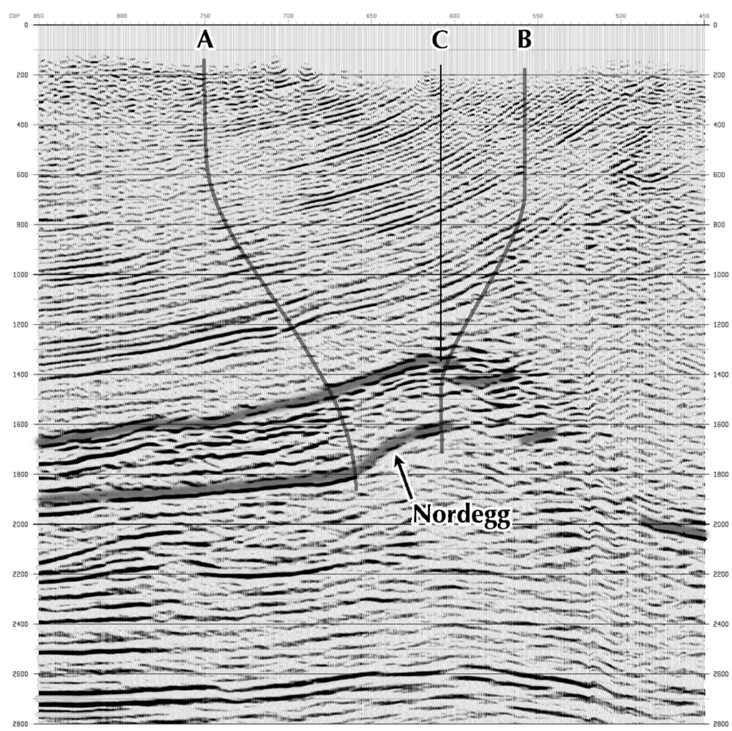

Figure 2. Prestack depth migration displayed in time.

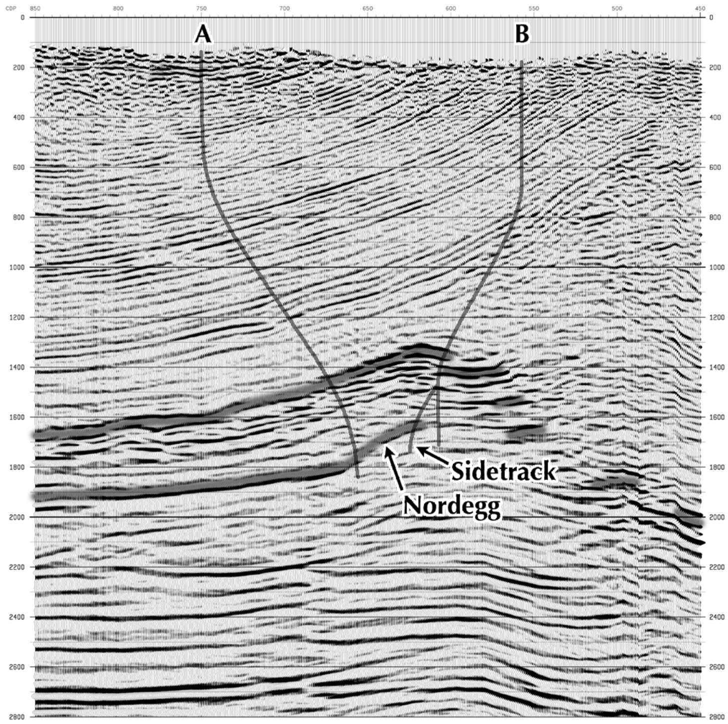

Figure 3. Prestack anisotropic depth migration displayed in time.

Two courses of action followed: (1) a dipmeter was ran from surface casing to TD and (2) the data were reprocessed anisotropic depth migration (ADM). In deriving the velocity model, several migrations using Thomsen's (1986) epsilon values ranging from 0.025 to 0.3 were compared to find the maximum reflector amplitude and continuity of reflection for the deeper reflectors as prescribed by Vestrum et al. (1998, 1999). The final ADM section is shown in Figure 3.

Results of the ADM showed the Nordegg reflector repositioned about 250 m southwest of its interpreted position in Figure 2. This is caused by dips of overlying strata in the west flank of the triangle zone. Results of the dipmeter confirmed that Well B drilled off the leading edge of the structure. Dips up to 70° were encountered near the bottom of the hole. A new target 175 m to the Southwest was chosen from the ADM and confirmed by dipmeter analysis.

The sidetrack, shown in Figure 3, was drilled from 2754 m to 3382 m TD and again logged by dipmeter. The sidetrack encountered formations predicted by the ADM processing and low dips, indicating that the sidetrack was near the crest of the structure, which again correlates well with the ADM section (Figure 3). Note also in Figure 3 that the new position of the structure created a better tie between the seismic events and the dipmeter from Well A.

Discussion and Conclusions

Although prestack time migration and prestack depth migration are considerable steps forward in thrust-belt seismic processing, ignoring seismic anisotropy in a dipping clastic overburden can lead to significant lateral-position errors on seismic data. In this case, the well trajectory penetrated horizontal seismic events and encountered 70° Northeast dips due to the lateral mispositioning of reflectors on the migrations that do not account for anisotropy. The position of the reflectors on the ADM section provides a better correlation between seismic and well data in both wells.

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